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Physical Model Studies of Head-Discharge Relationships for Steel Z-Section Water-Level Control Structures

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Physical Model Studies of Head-Discharge Relationships for Steel Z-Section Water-Level Control Structures

By Charles E. Rice and Wendell R. Gwinn[1]

ABSTRACT

Experiments were conducted in a 10- by 40-foot test basin at the Water Conservation Structures Laboratory, Stillwater, Okla. The Z-section structures were made with 0.062-inch-thick sheet steel to scale from field measurements, and fixed model topography was set to grade with 1- to 2-inch-thick concrete mortar on a compacted sand bed. Head-discharge relationships developed from rectangular-weir flow data for free-flow and submergence conditions did not adequately predict the discharge for the sinuous weir formed by the Z-section pilings. An equation developed by Villemonte (1947) from a series of tests on submerged sharp-crested weirs adequately predicted the submerged discharge. The approach conditions immediately upstream of the weir had a significant effect on the head-discharge relationship. The elevation there should be 0.5 foot or more lower than the weir-crest elevation to insure that the structure will control the flow, with the discharge being little affected by surface roughness. Index terms: head-discharge relationships, physical models, steel sheet pilings, waterflow, water-level control structures, weirs.

INTRODUCTION

Water-quality and nutrient-load studies, on a limited scale, were initiated in the Taylor Creek Watershed, Okeechobee County, Fla., in 1972 by the USDA (Allen et al. 1975). In early 1975 this watershed was identified by the Central and Southern Florida Flood Control District, now the South Florida Water Management District, as one of the major problem watersheds, with respect to nutrient loads, that empty into Lake Okeechobee (Davis and Marshall 1975), and a decision was made to increase the water-quality study on the watershed.

(*Continued on page 4.*)

FIGURE 1.—View of prototype structure S-13 from downstream.

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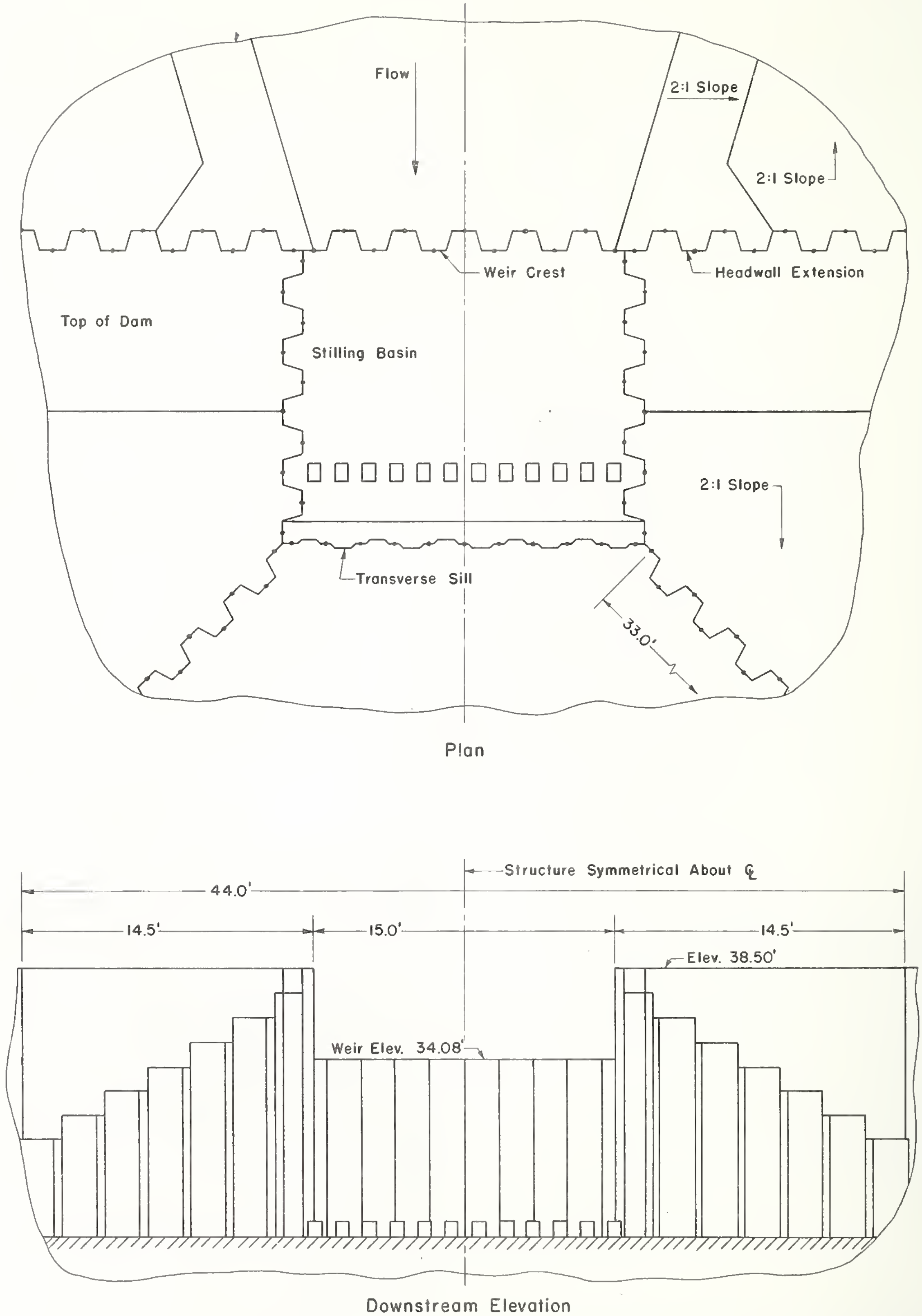

FIGURE 2.—Layout and dimensions of prototype structure S-13. (Adapted from maps furnished by W. R. McCall, district conservationist, Soil Conservation Service, Okeechobee County, Fla.)

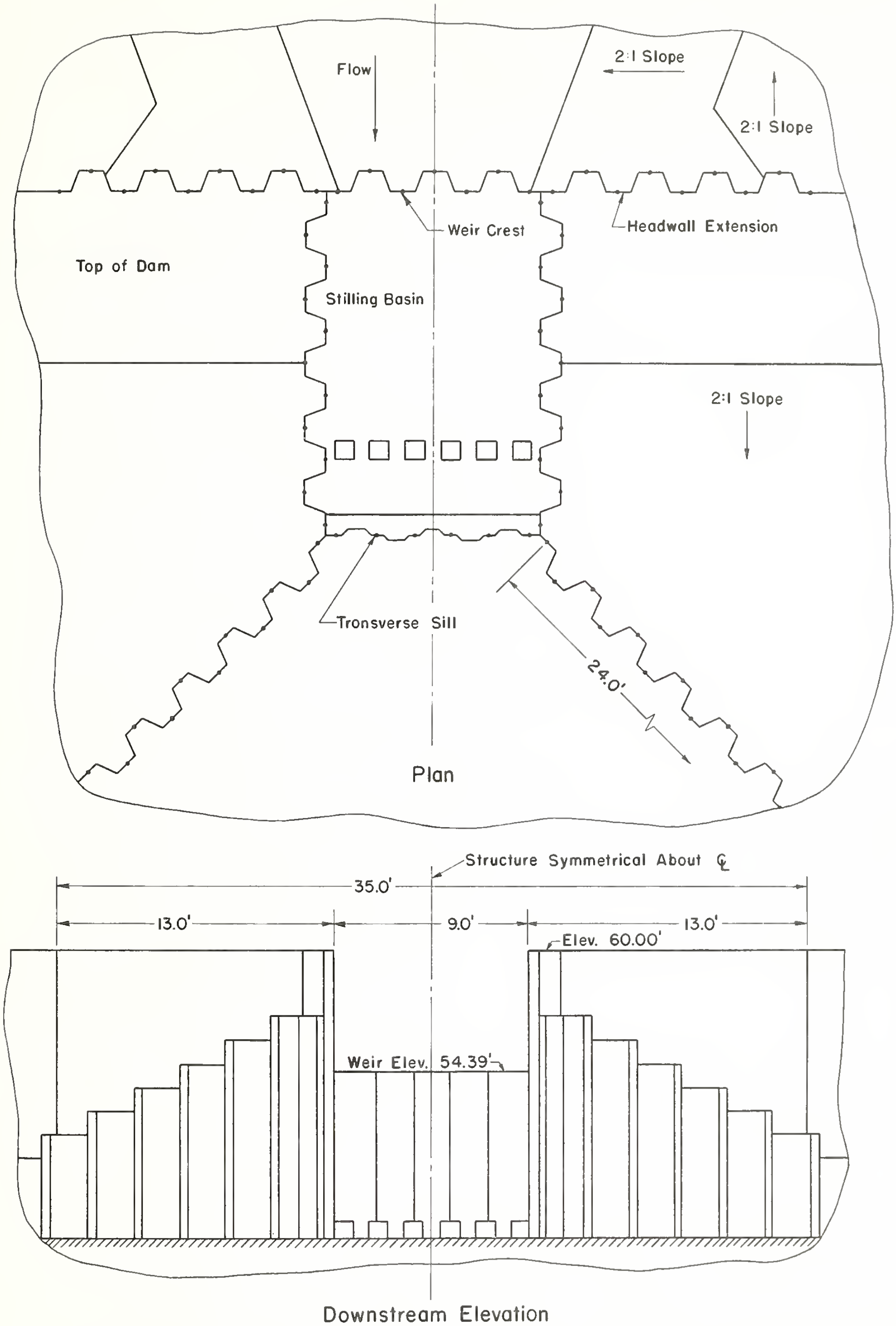

FIGURE 3.—Layout and dimensions of prototype structure S-13B. (Adapted from maps furnished by W. R. McCall, district conservationist, Soil Conservation Service, Okeechobee County, Fla.)

The flows through structures S-13 and S-13B were monitored as part of the total watershed water-quality study. These water-level control structures, made of steel-sheet pilings, were constructed in 1966 at the outlet and upstream of the outlet of watershed subunit W-13 on Otter Creek, a tributary of Taylor Creek. The structures were constructed under the authority of the Watershed Protection and Flood Prevention Act, Public Law 566 (Okeechobee Soil Conservation District 1959). Structure S-13 drains about 11 square miles and structure S-13B about 5.9 square miles of improved pasture used primarily for grazing dairy cattle. Stage and flow measurements were begun in July 1975. Paper-tape water-stage recorders were installed in October 1975, and automatic water samplers were installed immediately upstream of the two structures in March 1976.

A head-discharge rating was developed for structure S-13 by using the results of tests with rectangular thin-plate weirs for the high flows (Kindsvater and Carter 1959) and rectangular thin-plate weir data collected by D. K. McCool (Water Conservation Structures Laboratory, unpublished data) for flows in the clinging-nappe range. This rating could not be used with confidence because of the weir crest. The steel-sheet pilings are Z-section pilings, resulting in a sinuous weir crest. We assumed that as the head increased the effective weir-crest length would change from the sinuous length to the weir opening width and the flow could be predicted using rectangular-weir flow data. At what head this would occur was not known, making use of the developed rating questionable except at very low or very high flows. Field data were needed to identify the head range in which the change in the effective crest length would occur.

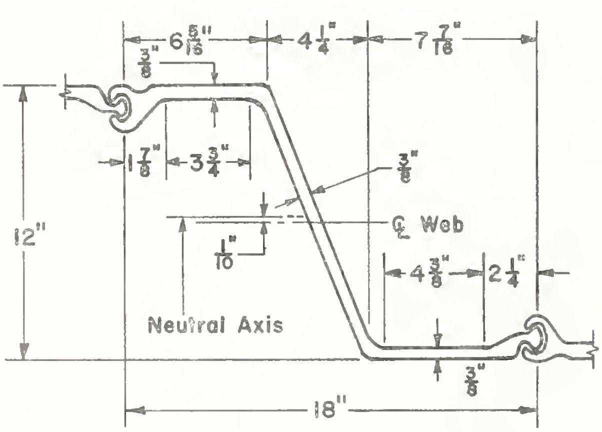

FIGURE 4.—Details and dimensions of a Z-section piling.

Field ratings were not available for the structures and obtaining head-discharge data at other than low flows did not appear probable because of a lack of either a suitable cross section or a bridge for cable measurements. Physical-model studies could be conducted to determine the head-discharge rating for structures S-13 and S-13B. This would (1) eliminate the need for a field setup, including a permanent channel measurement section and foot bridge, and any attendant modifications or alterations of the structure or channel to obtain the rating by field measurement and (2) provide a rating for the anticipated range of heads, which would be almost impossible to obtain in the field because of the infrequency of large flows and the unlikelihood of personnel being at the stations at suitable times to make the measurements.

In late 1978, the Water Conservation Structures Laboratory, Stillwater, Okla., initiated a model study to rate structure S-13. In June 1979, the water-quality work on the Taylor Creek Watershed was expanded. In addition to increasing the nutrient pollution work, a study was started to determine the water quality before and after initiation of best management practices in the watershed. This new emphasis on water quality increased the need for and importance of head-discharge ratings for structures S-13 and S-13B.

This report presents the descriptions of the prototypes and physical models, the procedures followed, and the analyses and results of the physical-model studies conducted to determine the head-discharge ratings for structures S-13 and S-13B.

PROTOTYPES

Structures S-13 and S-13B are water-level control structures constructed with section MZ 27 steel sheet pilings (United States Steel Corp.). Figure 1 is a picture of structure S-13. The layout and dimensions of the field structures are presented in figures 2 and 3, and details and dimensions of a Z-section piling are presented in figure 4. Figure 5 shows the layout and topography for structure S-13, and figures 6 and 7 show the layout and topography for structure S-13B for two approach conditions. Figure 6 is the current field approach topography for structure S-13B, and figure 7 is the topography for this structure with a layer of concrete-bag riprap material removed immediately

(*Continued on page 8.*)

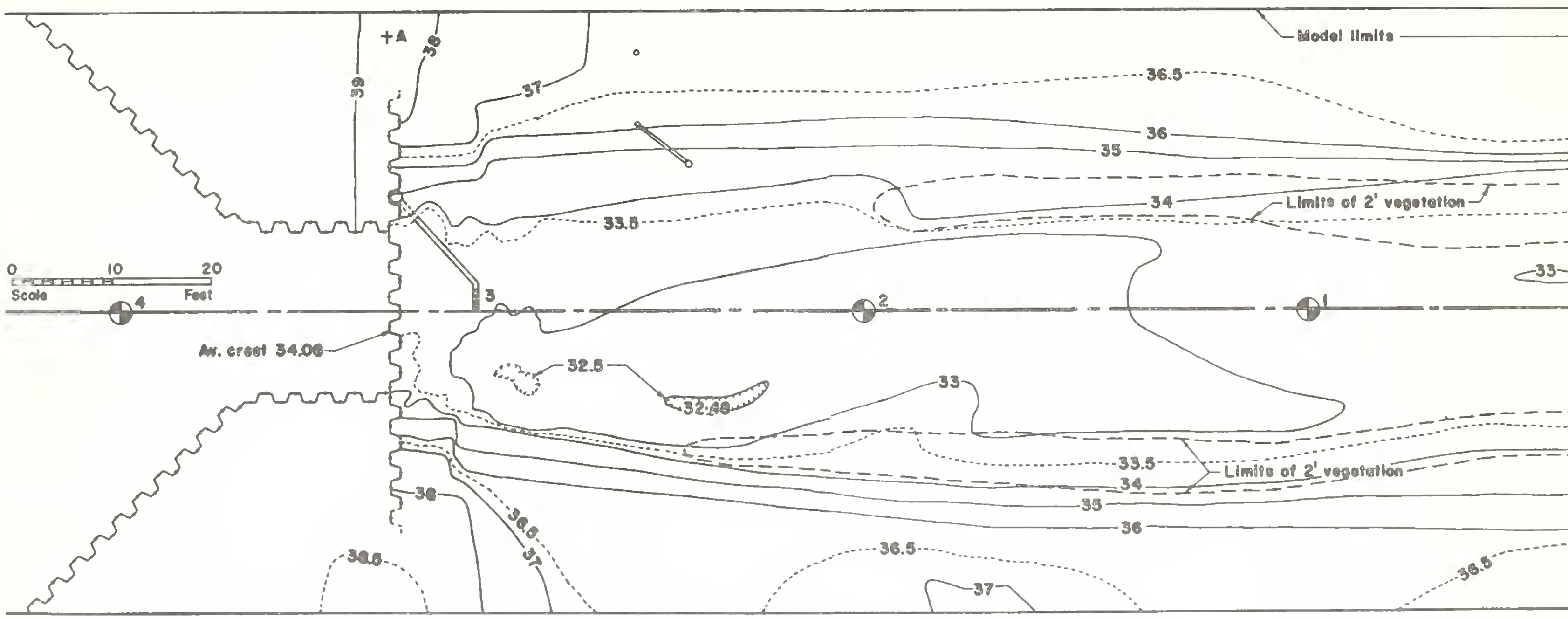

FIGURE 5.—Layout and topography for prototype structure S-13.

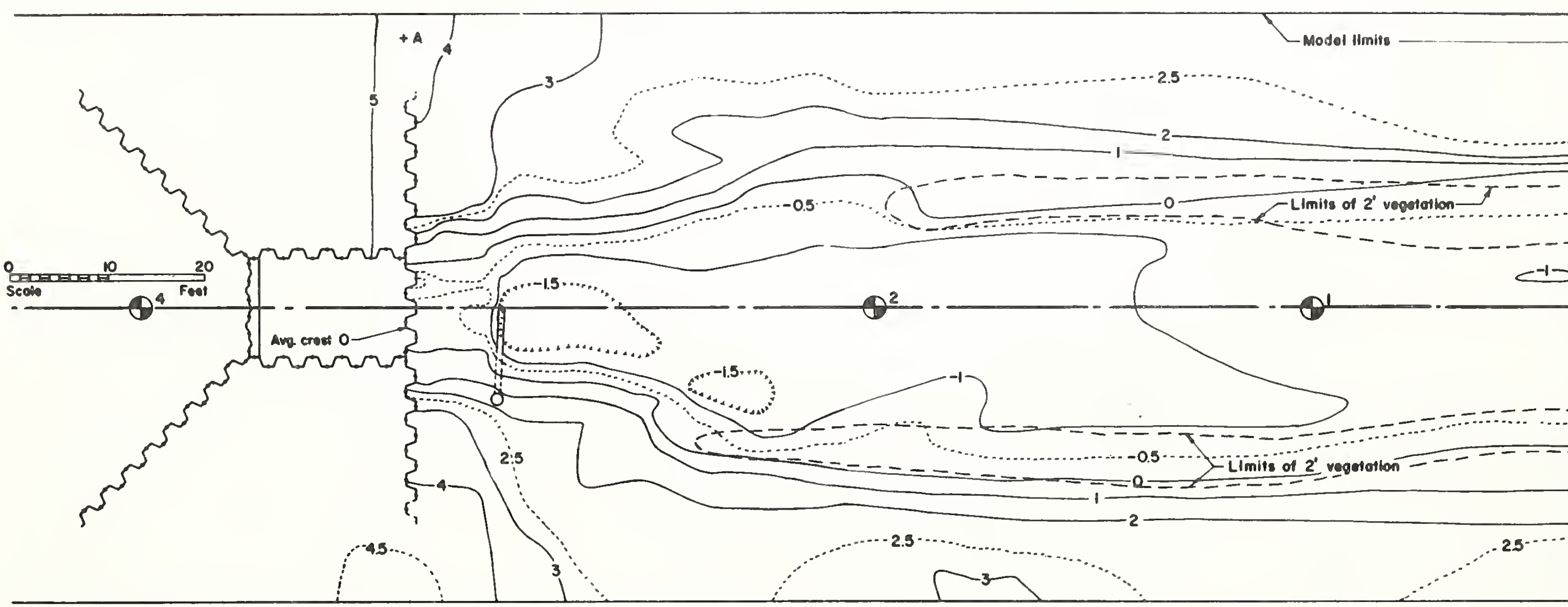

FIGURE 6.—Layout and topography for prototype structure S-13B, showing current field approach condition.

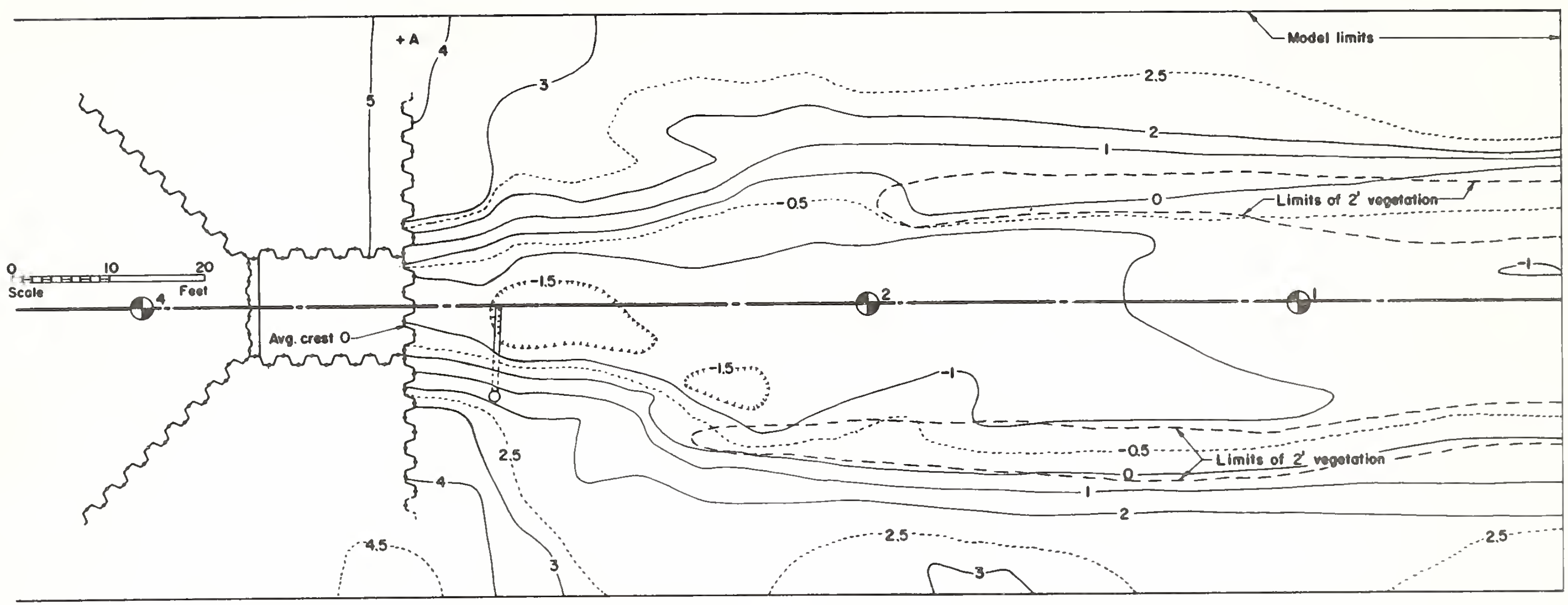

FIGURE 7.—Layout and topography for prototype structure S-13B, with layer of concrete-bag riprap material removed immediately upstream of weir crest.

Table 1.—Model-prototype transfer relationships

Property	Model scale
Length	1:6
Area	1:36
Time	1:2.45
Discharge	1:88.18

FIGURE 8.—Model of structure S-13 during construction.

upstream of the weir crest. Structure S-13B was also tested with the approach topography at or very near the weir-crest elevation.

MODELS

DESCRIPTION

A 10- by 40-foot test basin at the Water Conservation Structures Laboratory was used for the model studies. The size of the basin permitted a model-prototype length scale of 1:6. Since the flow over a weir is controlled by the force of gravity on a free water surface, similarity of model and prototype was based on the Froude model law. The model-prototype relationships are presented in table 1.

The model structures were made with 0.062-inch-thick sheet steel to scale from field measurements. A concrete cutoff wall was used to prevent seepage (fig. 8). The fixed model topography was set to grade with 1- to 2-inch-thick concrete mortar on a compacted sand bed. The channel downstream was not modeled because it would not have affected the flow through the structure. The completed model of structure S-13 is shown in figure 9.

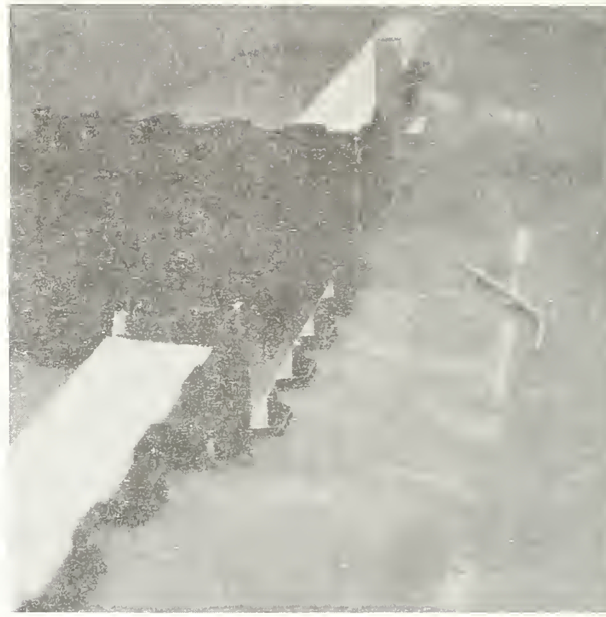

FIGURE 9.—Model of structure S-13 after completion.

For structure S-13 the complete upstream topography was modeled from a field survey, but for structure S-13B only the immediate approach topography (an area about 10 feet long and 22 feet wide) was modeled from a field survey. The approach channel for structure S-13B was shaped for about 40 feet upstream of the crest, and the remaining topography was the same as that of structure S-13. Even though the complete upstream area was not modeled for structure S-13B, the results should be valid because of the flat gradient of the channel upstream and the ponding of water upstream of the structure.

SUPPORT EQUIPMENT

The water supply for the model was gravity fed through a 12-inch pipeline from Lake Carl Blackwell. Calibrated sharp-edged orifice plates, inserted one at a time in the supply line, were used to measure the flow rate, which was controlled by an outlet valve. The discharge was determined from rating tables, using the differential head (measured to the nearest 0.1 inch of water) across the orifice. A

Table 2.—Model test conditions

Structure	Experiment	Crest	Surface[1]	Discharge and topography
S-13	A	Sinuous	Smooth	Free flow, current field topography.
S-13	B	do	do	Submerged flow, current field topography.
S-13	C	Straight	do	Free flow, current field topography.
S-13B	1	Sinuous	do	Free flow, topography about zero to 0.06 ft below crest elevation.
S-13B	2	do	Roughened	Free flow, topography about zero to 0.06 ft below crest elevation.
S-13B	3	do	Smooth	Free flow, current field topography.
S-13B	4	do	Roughened	Free flow, current field topography.
S-13B	5	do	Smooth	Free flow, topography about 1.0 ft below crest elevation.
S-13B	6	Straight	do	Free flow, topography about 1.0 ft below crest elevation.

[1]Smooth surface is a trowel finish on concrete mortar surface; prototype Manning *n* is about 0.013. Roughened surface has pea gravel (3.4- to 4.0-mm diameter) cemented to surface; prototype Manning *n* is about 0.020.

floating wave suppressor and baffles were used in the forebay to still the water.

A water-level recorder, installed in a stilling well in the forebay, was used as a visual indicator of steady flow in the model. The heads were measured to the nearest 0.001 foot in four point-gage wells mounted on the basin wall. These wells were connected with 0.25-inch pipe to each of the gages shown in figures 5-7. A liquid-in-glass thermometer mounted in the supply line was used to measure the water temperature.

TEST CONDITIONS AND PROCEDURES

Table 2 presents a description of the structures and the approach conditions tested with structures S-13 and S-13B. Different approach conditions were studied with structure S-13B to determine the effect of the approach topography and surface roughness on the head-discharge relationship.

After construction, the model dimensions, elevations, and point-gage zero elevations were determined. Free-flow tests were then run for structures S-13 and S-13B, going from maximum flow, through medium flow, to minimum flow increments. During the test flow, point-gage readings were made to determine water-surface elevations in the headpool, manometer readings were made to determine the discharge, water temperature was recorded, and appropriate notes and pictures were made as required.

Submergence data were obtained at two free-flow discharges for structure S-13. The free-flow discharge was set, and a tailwater gate was raised in increments from zero to about 95 percent submergence. At each increment, tailwater elevation measurements, in addition to the measurements taken for free-flow tests, were obtained.

ANALYSES, RESULTS, AND DISCUSSION

Head-Discharge Ratings

Tailwater elevation records showed that these structures would operate with free flow; therefore, the major emphasis was to rate the structures for free-flow discharge. However, the submergence data were obtained in case some future modification downstream of the structures might result in increased tailwater elevation and submergence.

Free-flow conditions

The tailwater gates were opened and flow was controlled by the structures. The following equation was used in the analysis of the data:

$$Q=CL_aH^{1.5}, \tag{1}$$

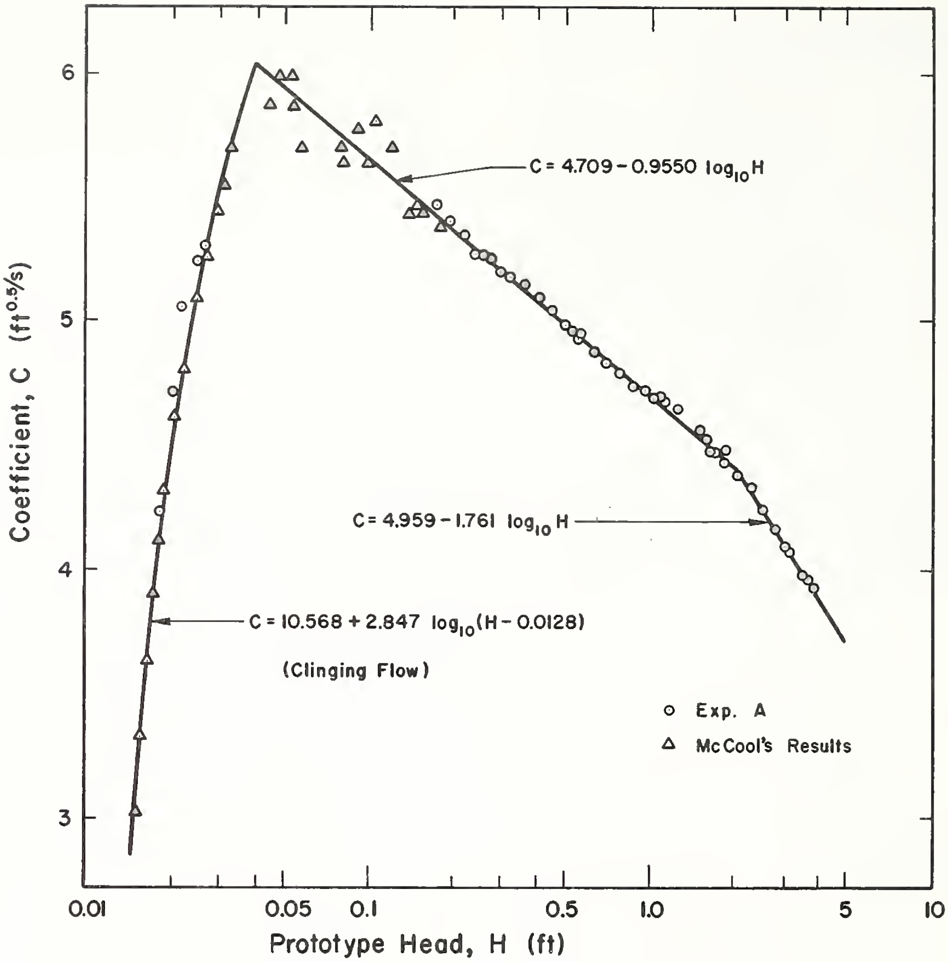

FIGURE 10.—Discharge coefficient versus head for structure S-13, experiment A.

Table 3.—Constants for equation of discharge

Structure	Experiment	Head range (ft)	Constant A	Constant B
S-13	A	2.07 to 4.00	4.959	−1.761
		0.04 to 2.06	4.709	−0.955
S-13B	3	2.79 to 4.00	4.888	−1.830
		0.48 to 2.78	4.512	−0.9828
		0.05 to 0.47	4.344	−1.498
S-13B	4	2.90 to 4.00	4.886	−1.848
		0.48 to 2.89	4.429	−0.8575
		0.05 to 0.47	4.190	−1.600
S-13B	5	2.87 to 4.00	4.946	−1.966
		0.57 to 2.86	4.509	−1.013
		0.05 to 0.56	4.388	−1.500

where Q=total discharge (cubic feet per second),
C=discharge coefficient ($\text{feet}^{0.5}$/second),
L_a=average length of weir opening (feet) or

$$L_a = \frac{1}{n}\sum_{i=1}^{n} L_i,$$

H=head on weir (feet) measured at gage 3,
and n=number of rating table ΔH increments in the given H.

The length of the weir opening (L_i) for the field structures varied with elevation and is defined by the equation

$$L_i = a + bH, \tag{2}$$

where coefficients a (L intercept) and b (slope of straight-line relationship) equal, respectively, 15.04

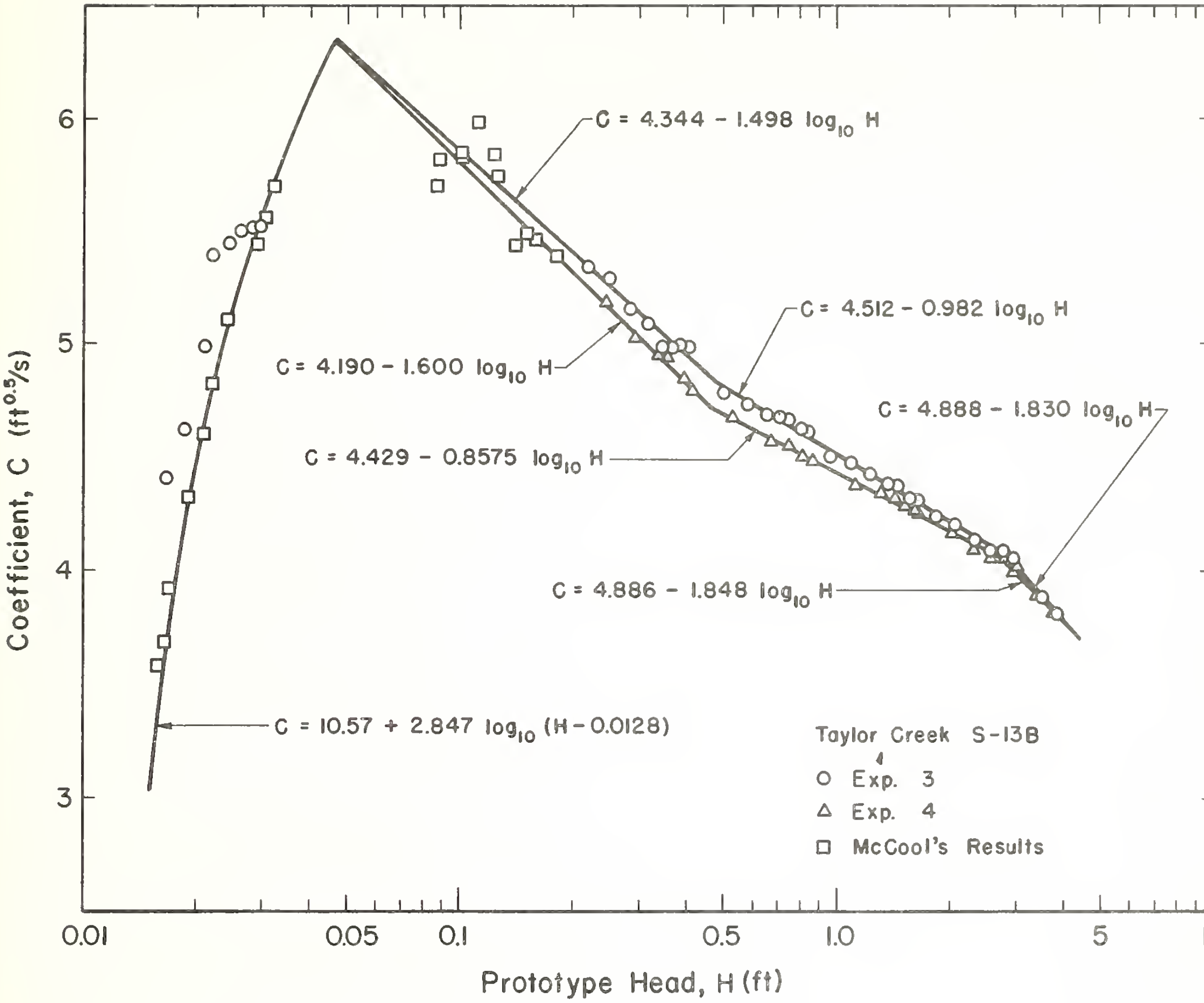

FIGURE 11.—Discharge coefficient versus head for structure S-13B, experiments 3 and 4.

feet and −0.009 for structure S-13 and 8.94 feet and −0.012 for structure S-13B.

The coefficient (C) for the springing-free flows (H>0.04 foot) was computed using the model data and equation 1. The model coefficient and H values were converted to prototype values and fitted to the equation

$$C=A+B\log_{10}(H), \tag{3}$$

where A and B are constants determined by a least square fit of the C versus H data. The constants are listed in table 3 for experiments A and 3-5. Equation 3 was substituted into equation 1 for C to calculate the rating table values in the springing-free flow range.

For the clinging-nappe flows (H<0.04 foot), the coefficient (C) was calculated using D. K. McCool's data and equation 1 and was fitted to the equation

$$C=10.57+2.847\log_{10}(H-0.0128). \tag{4}$$

Equation 4 was substituted into equation 1 for C to calculate the rating table values in the clinging-nappe flow range.

The procedure of calculating C and expressing it as a function of H is a convenient and accurate method of determining the head-discharge rating tables for the structures.

The results of the tests for experiments A and 3-5, in prototype values, are presented in figures 10-12.

The data for head values of less than 0.04 foot are in the clinging-nappe range. Once the nappe started to cling, the model-prototype scale relationship did not apply; thus, the results from the model are equivalent to full-scale test data. The prototype

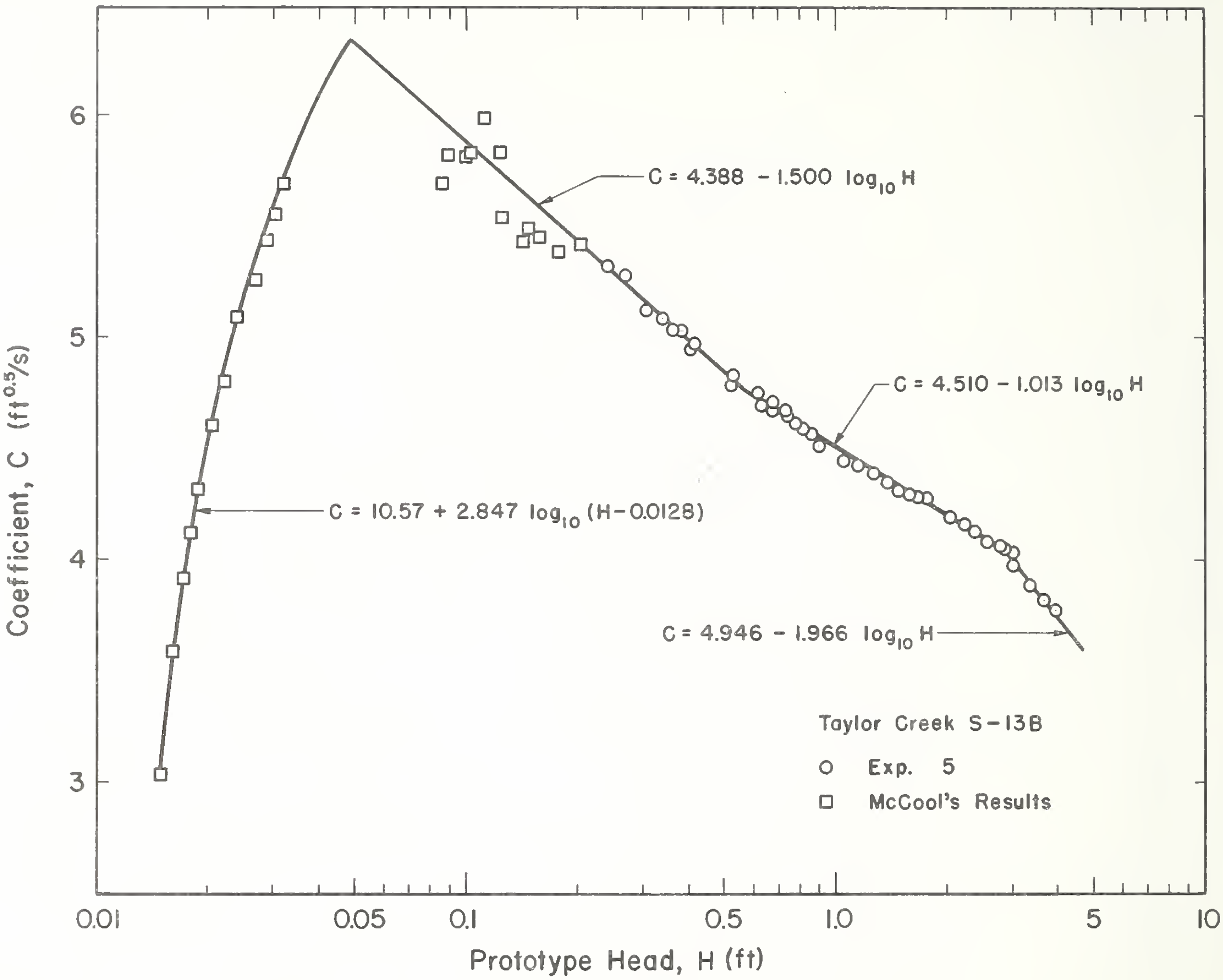

FIGURE 12.—Discharge coefficient versus head for structure S-13B, experiment 5.

crest thickness was 0.375 inch, and the model crest thickness was 0.062 inch. Because of this large difference in crest thickness, we decided to use some results obtained by D. K. McCool to determine the *C* versus *H* relationship in this range. His tests were with a weir having a crest thickness of 0.164 inch, which more nearly simulated the weir-crest thickness of the prototype. Also, McCool's head measurements were made with a micrometer depth gage and are more accurate than the model data. The model data in the clinging range are in fairly good agreement with McCool's results (figs. 10-12), which lends confidence that the relationship for *C* and *H* using McCool's data is adequate for the prototype structure.

No data were obtained in the prototype head range of 0.030 to 0.164 foot with the model. To evaluate how well the extended straight-line model relationships define this portion of the *C* versus *H* relationship, McCool's results were used. Although there is considerable scatter to his data, they do fit the extended model curves well enough to give confidence that the extended curves will adequately define *C* in this head range.

At prototype heads of about 2.05 feet for structure S-13 and 2.9 feet for structure S-13B, a change in slope occurred in the *C* versus *H* relationship due to the change in effective length of the weir crest with increasing head. At low flows there was a distinctive pattern of corrugations, parallel to the flow lines, in the upper nappe surface. The valleys and ridges of the corrugations were coincident with a crest trough projecting upstream and downstream, respectively. As the prototype heads approached

the heads listed above, the pattern of corrugations became less and less evident in the upper nappe surface. At prototype heads greater than these, the upper nappe surface appeared smooth. At a head of about 2.5 feet for structure S-13, some flow began to move overland around the structure. Thus, at heads greater than about 2.5 feet, the flow measured at structure S-13 was not the total flow of the stream.

Submergence conditions

Results of the submergence tests for structure S-13, run at two free-flow discharges, are presented in figure 13. The following equation, developed by Villemonte (1947) from a series of tests on submerged sharp-crested weirs, gives a reasonable fit for the submergence test data:

$$Q_s/Q=[1-(T/H)^{1.5}]^{0.385}, \qquad (5)$$

where Q_s=submerged discharge (cubic feet per second),
Q=free-flow discharge (cubic feet per second) for a head of H,
T=tailwater head (feet),
and H=head (feet) measured at gage well.

Head-Discharge Relationships for Various Approach Conditions

Head-discharge relationships were determined from the model studies and from using the best available data for structures S-13 and S-13B. These data were then applied to the results of Kindsvater and Carter (1959), with sinuous weir-crest lengths and weir-opening widths as the crest lengths in the equations. We assumed, before the model tests were run, that the effect of the sinuous weir crest would become insignificant in the head range of 1 to 2 feet and that the effective weir-crest length above this head would be equal to the weir-opening width. It followed then that the discharge could be predicted with the Kindsvater and Carter equations. The results in figures 14 and 15 show that this did not occur and that some effect of the sinuous weir crest persisted at the maximum heads tested. At what head the weir opening width became the effective crest length cannot be determined from these results.

To determine the approximate head where the effect of the sinuous weir crest ceased and the

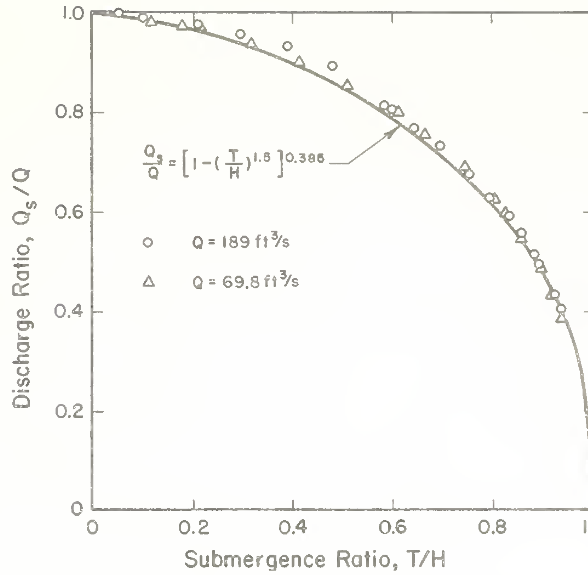

FIGURE 13.—Submergence flow results.

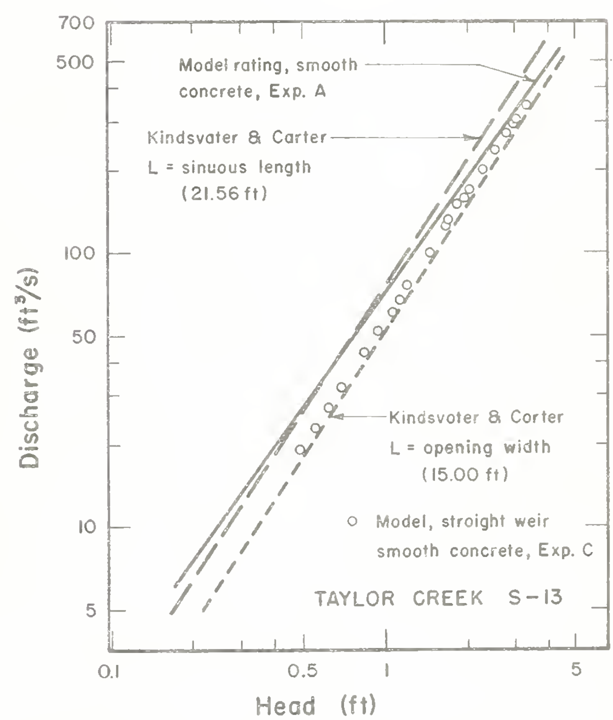

FIGURE 14.—Discharge versus head for structure S-13, experiments A and C.

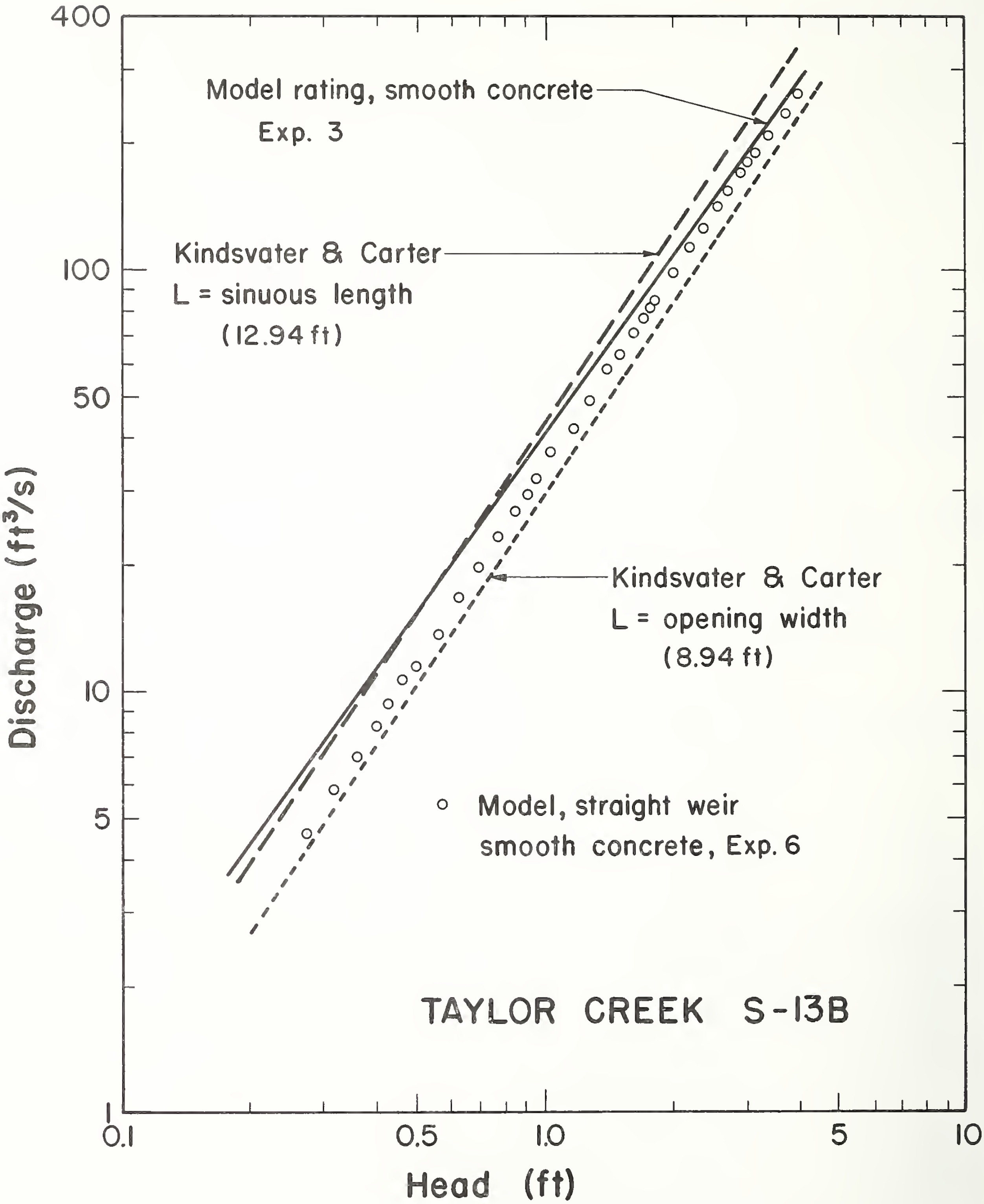

FIGURE 15.—Discharge versus head for structure S-13B, experiments 3 and 6.

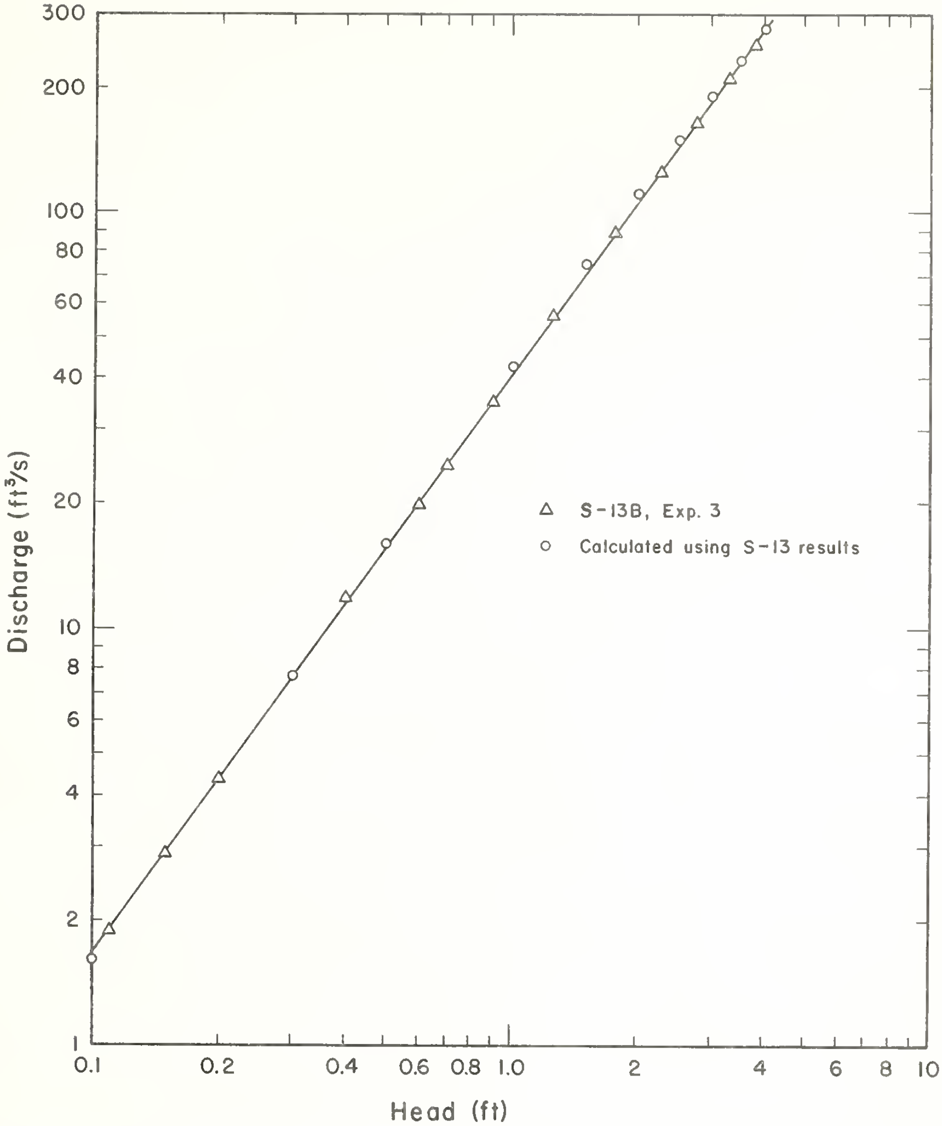

FIGURE 16.—Head-discharge values from S-13B model results and values calculated using coefficients from S-13 model results for comparison.

weir-opening width became the effective crest length, a straight weir crest having the same thickness as that used for the sinuous weir crest was installed in each model and tested. For structure S-13, the crest was set on top of the sinuous weir crest, so its elevation was about 1 inch higher than the original crest. This should not have caused a significant difference in the hydraulic performance of the model relative to the approach conditions and the velocity of approach. Thus, a direct comparison between the sinuous and straight weir crests should be valid. Data for the straight weir crest for structure S-13 are presented in figure 14. For structure S-13B, the straight weir crest was set at the same elevation as the sinuous weir crest. The results for structure S-13B are presented in figure 15.

The slope of the Q versus H data for the straight crest is about 1.53:1, compared to about 1.50:1 for the Kindsvater and Carter predictions and a lesser slope for the sinuous crest. The data observed for the straight-crest discharge are greater than those predicted by the Kindsvater and Carter equations using the weir-opening width as the crest length. The straight-crest data are linear in log-log space. The Q versus H data for the sinuous crest are not linear but have a slightly decreasing slope with increasing head due to the weir-crest length

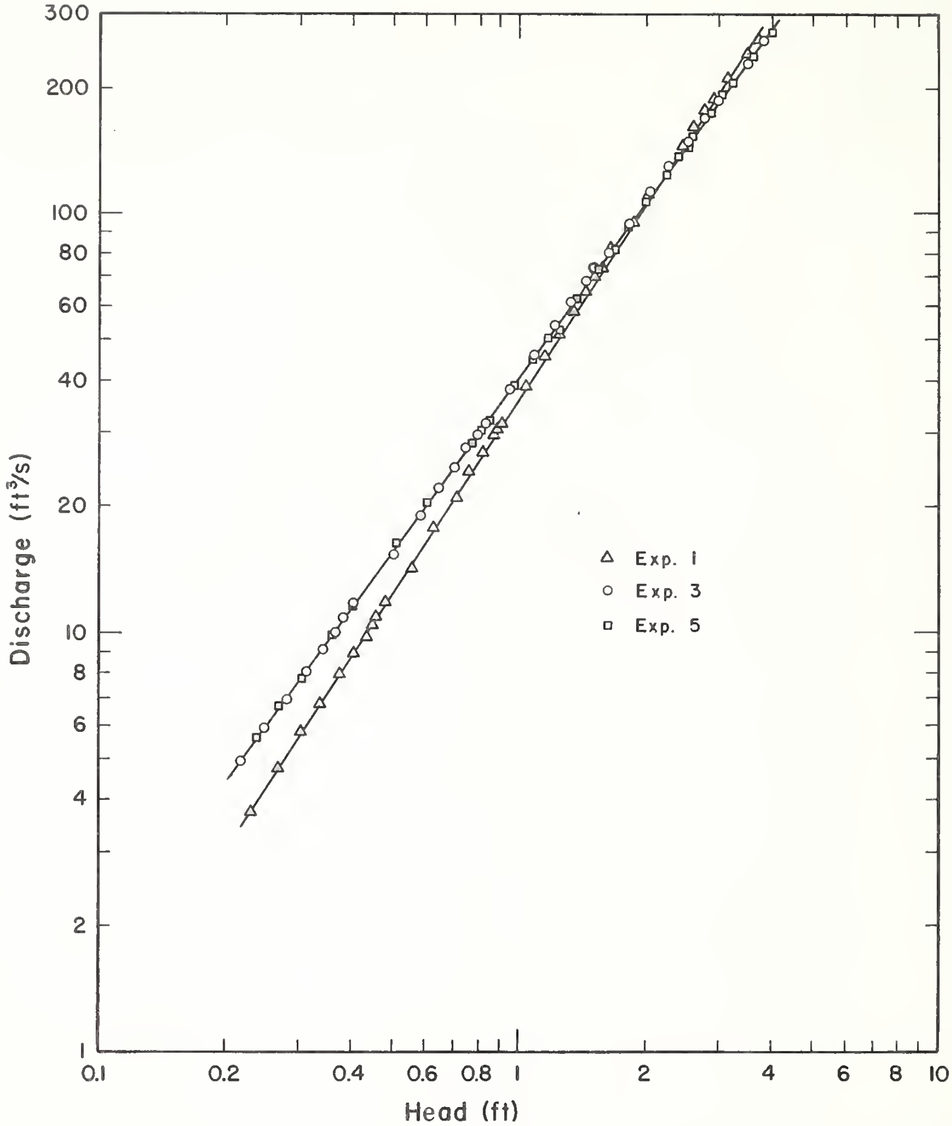

FIGURE 17.—Discharge versus head for structure S-13B, experiments 1, 3, and 5. Approach topography for experiments 1, 3, and 5 was at weir-crest elevation, about 0.5 foot below weir-crest elevation, and about 1.0 foot below weir-crest elevation, respectively.

being slowly reduced as the head increases. By extending the sinuous- and straight-crest data beyond the observed values, the two relationships converge to a single curve at a head of about 4.5 to 5.0 feet. Above this head, the sinuous effect is completely voided, and the effective crest length is equal to the weir-opening width; thus, the structure performs similarly to a straight rectangular weir.

Figure 16 presents head-discharge values observed from the S-13B model results and the values calculated with equation 1 using the coefficients from the S-13 model results and the weir-opening width for structure S-13B. The approach conditions (experiments A and 3) for the two structures were similar. Structure S-13 had an opening width of about 15 feet, and structure S-13B had an opening width of about 9 feet. The results by the two methods are almost identical, which shows that the results for structure S-13 could have been used to develop a rating for structure S-13B with acceptable accuracy. This is not necessarily true for all structures, but only for those with similar approach conditions.

Figure 17 presents the head-discharge relationships from the S-13B model results for experiments

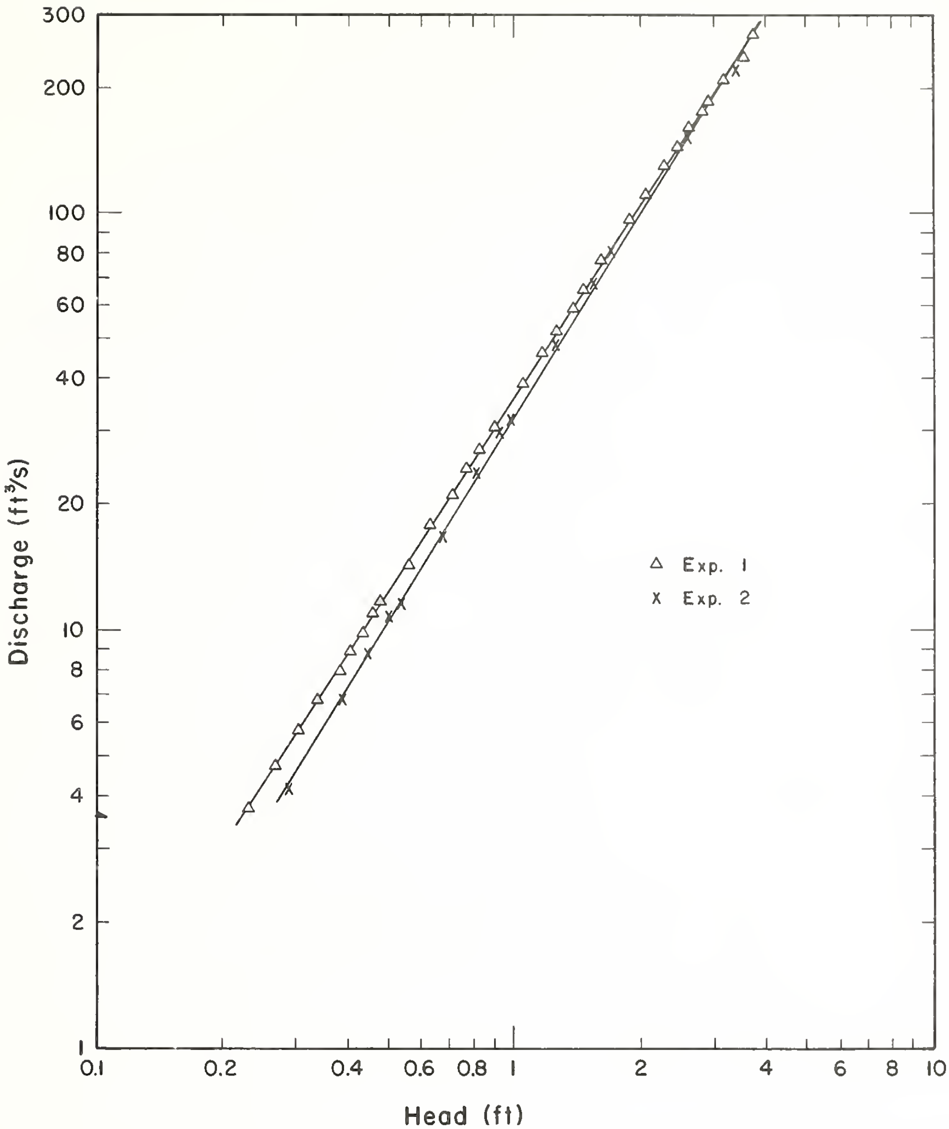

FIGURE 18.—Discharge versus head for structure S-13B, experiments 1 and 2. Approach topography for both experiments was at weir-crest elevation.

1, 3, and 5, for which the approach conditions were topography at the weir-crest elevation, topography about 0.5 foot below the weir-crest elevation, and topography about 1.0 foot below the weir-crest elevation, respectively. The surface was smooth in all the experiments. The results show that the head-discharge relationships for experiments 3 and 5, the lower approach topographies, are almost identical and are significantly different from the head-discharge relationship for experiment 1 in the lower head range. These results indicate that, for the conditions in experiment 1, there was channel control at the lower heads and that the discharge would have been affected by the channel surface characteristics. For the conditions in experiments 3 and 5, the structure was the control and the discharge was little affected by the channel surface characteristics, as was shown by the results presented in figure 11. These results (fig. 17) suggest that the topography immediately upstream of the weir-crest elevation should be lower than the weir-crest elevation by 0.5 foot or more so that the structure will control the flow and be little affected by the channel surface characteristics.

Figure 11 presents the discharge coefficients for structure S-13B for the current field topography

with a smooth approach (experiment 3) and with a roughened approach (experiment 4). The maximum difference in the discharge coefficients for the two conditions is about 3 percent and occurs at a head of about 0.4 foot. These results indicate that surface roughness has a minor effect on the head-discharge relationship for this approach condition.

Figure 18 presents the head-discharge relationships for structure S-13B for the smooth (experiment 1) and roughened (experiment 2) surfaces, with the approach topography at the weir-crest elevation. These results show that surface roughness has a significant effect on the head-discharge relationship at the low flows for this approach condition. For example, at a head of about 0.3 foot the difference in discharge for the two roughness conditions is about 24 percent. At the higher discharges (H>1.5 feet) surface roughness does not affect the head-discharge relationship.

As previously stated, equation 5 for submerged flow conditions was developed by Villemonte (1947) from a series of tests on submerged sharp-crested weirs. The model data for structure S-13 fit the equation within an error of 5 percent, with most errors occurring in the 3-percent range (fig. 13). Because of this good agreement of the S-13 model results with Villemonte's results, submergence tests were not run for structure S-13B. Use of equation 5 requires the free-flow (Q versus H) relationship.

CONCLUSIONS

Rectangular-weir flow data cannot be used to predict the discharge for multiple-oblique weirs of the type studied. If the sinuous length is used as the crest length, the discharge may be adequately predicted only at low flows; but, if the weir-opening width is used as the crest length, the discharge may be adequately predicted only at high flows. In the transition range, where the effective crest length changes from the sinuous length to the weir-opening width, the discharge will not be adequately predicted. Also, the head range for the transition cannot be predicted with the present data.

Equations 1-4 and the constants in table 3 can be used to determine the head versus discharge relationship for structures S-13 and S-13B under free-flow conditions.

Villemonte's equation for submerged sharp-crested weir flow (equation 5) will adequately predict the submerged discharge for structures S-13 and S-13B under any submergence condition.

The head-discharge relationship for structure S-13B (9-foot weir-opening width) was adequately predicted using the discharge coefficients calculated for structure S-13 (15-foot weir-opening width). The two structures had similar approach conditions upstream of the weir.

The approach condition immediately upstream of the weir had a significant effect on the head-discharge relationship. The elevation there should be 0.5 foot or more lower than the weir-crest elevation to insure that the structure will control the flow, with the discharge being little affected by surface roughness.

REFERENCES

Allen, L.H., Jr.; Stewart, E.H.; Knisel, W.G., Jr.; and Slack, R.A.
1975. Seasonal variation in runoff and water quality from the Taylor Creek Watershed, Okeechobee County, Florida. Proc. Soil Crop Sci. Soc. Fla. 35: 126-138.

Davis, F.E., and Marshall, M.L.
1975. Chemical and biological investigations of Lake Okeechobee, January 1973-June 1974. Interim report. Central and Southern Florida Flood Control District (West Palm Beach, Fla.) Tech. Publ. 75-1, 91 pp.

Kindsvater, C.E., and Carter, R.W.
1959. Discharge characteristics of rectangular thin-plate weirs. Trans. Am. Soc. Civ. Eng. 124: 772-801.

Okeechobee (County, Fla.) Soil Conservation District.
1959. Work plan for Taylor Creek Watershed, Okeechobee County, Florida, 44 pp. Available from Soil Conservation Service, Federal Building, Gainesville, Fla. 32604.
1966. Supplemental watershed work plan, 20 pp. Available from Soil Conservation Service, Federal Building, Gainesville, Fla. 32604.

Villemonte, J.R.
1947. Submerged-weir discharge studies. Eng. News-Rec., vol. 139, pt. 2, pp. 866-869.

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